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I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation and Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein together with the Statement of inventorship and of right to grant of a Patent (Form 7/77), which was subsequently filed.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

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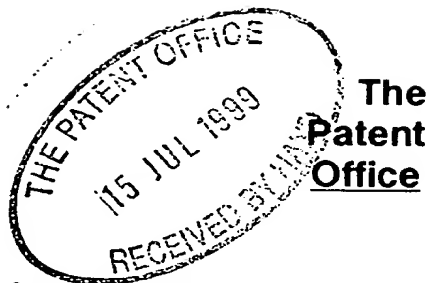
Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

*Andrew Gersey*

Dated 7 January 2000

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15 JUL 1999

**Statement of inventorship and of  
right to grant of a patent**

The Patent Office  
Cardiff Road  
Newport  
Gwent NP9 1RH

1. Your reference  
**1830601/AM**
2. Patent Application Number  
accompanying application reference 1830601  
**9916676.1**
3. Full name of the or each applicant  
**Scientific Generics Limited**
4. Title of the invention  
**EFFICIENT OPTICAL SOURCE FOR WEAPON SIGHTS**
5. State how the applicant(s) derived the right from the inventor(s) to be granted a patent  
**BY VIRTUE OF EMPLOYMENT.**
6. How many, if any additional Patents Forms  
7/77 are attached to this form?  
**NONE**
11. I/We believe that the person(s) named over the page (and on any extra copies of this form) is/are  
the inventor(s) of the invention which the above patent application relates to.  
  
Signature Beresford & Co Date 15 July 1999  
**BERESFORD & Co**
12. Name and daytime telephone number of  
person to contact in the United Kingdom  
**ALAN MACDOUGALL**  
**Tel: 0171-831-2290**

Patents Form 7/77

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7701623001

Patents Form 1/77  
Patents Act 1977  
(Rule 16)



**The  
Patent  
Office**

16-JUL-99 E462505-28 002917  
LP01/7700 0.00 - 9916676.1

**15 JUL 1999**

**Request for grant of a patent**

The Patent Office  
Cardiff Road  
Newport  
Gwent NP9 1RH

1.	Your reference	
	1830601/AM	
2.	Patent Application Number	
	<b>9916676.1</b>	
3.	Full name, address and postcode of the or of each applicant ( <i>underline all surnames</i> )	
	Scientific Generics Limited Harston Mill Harston Cambridgeshire CB2 5NH	
	Patents ADP number ( <i>if known</i> )	
	5693874002	
	If the applicant is a corporate body, give the country/state of its incorporation	Country: ENGLAND State:
4.	Title of the invention	
	EFFICIENT OPTICAL SOURCE FOR WEAPON SIGHTS	
5.	Name of agent	Beresford & Co
	"Address for Service" in the United Kingdom to which all correspondence should be sent	2/5 Warwick Court High Holborn London WC1R 5DJ
	Patents ADP number	1726001
6.	Priority details	
	Country	Priority application number
		Date of filing

**Patents Form 1/77**

7. If this application is divided or otherwise derived from an earlier UK application give details

Number of earlier of application

Date of filing

8. Is a statement of inventorship and or right to grant of a patent required in support of this request?

YES

9. Enter the number of sheets for any of the following items you are filing with this form.

Continuation sheets of this form

Description

7 / 2

Claim(s)

Abstract

Drawing(s)

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and  
right to grant of a patent (*Patents form 7/77*)

1 + 3 COPIES

1 / 2

Request for preliminary examination  
and search (*Patents Form 9/77*)

Request for Substantive Examination  
(*Patents Form 10/77*)

Any other documents  
(*please specify*)

11. I/We request the grant of a patent on the basis of this application

Signature

  
BERESFORD & Co

Date 15 July 1999

12. Name and daytime telephone number of  
person to contact in the United Kingdom

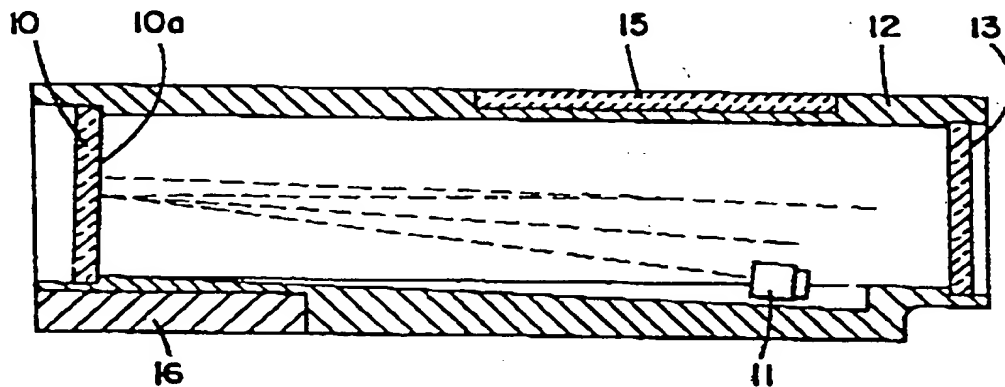
ALAN MACDOUGALL

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## Efficient Optical Source for Weapon Sights

A class of weapon sights known as red-dot sights employ an optical source which is imaged at infinity through an optical system typically of unit magnification, such that a spot of light of small angular extent appear superimposed on the target. Such devices typically employ a Light Emitting Diode (LED) optical source, although devices using ambient light and radioactive light sources are also known.

A sight employing an LED source is described in US patent number US005189555, which is incorporated herein for reference. The optical arrangement of US005189555 is shown below.



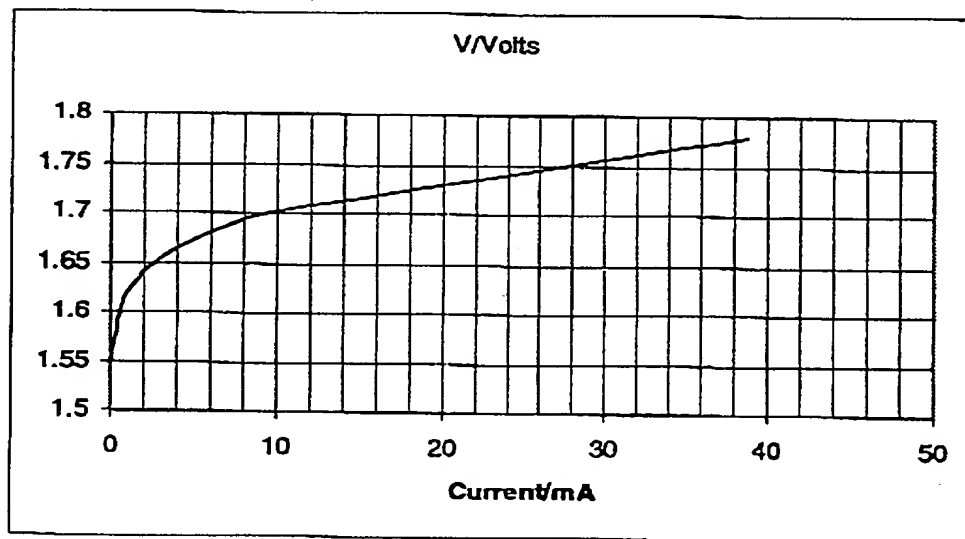
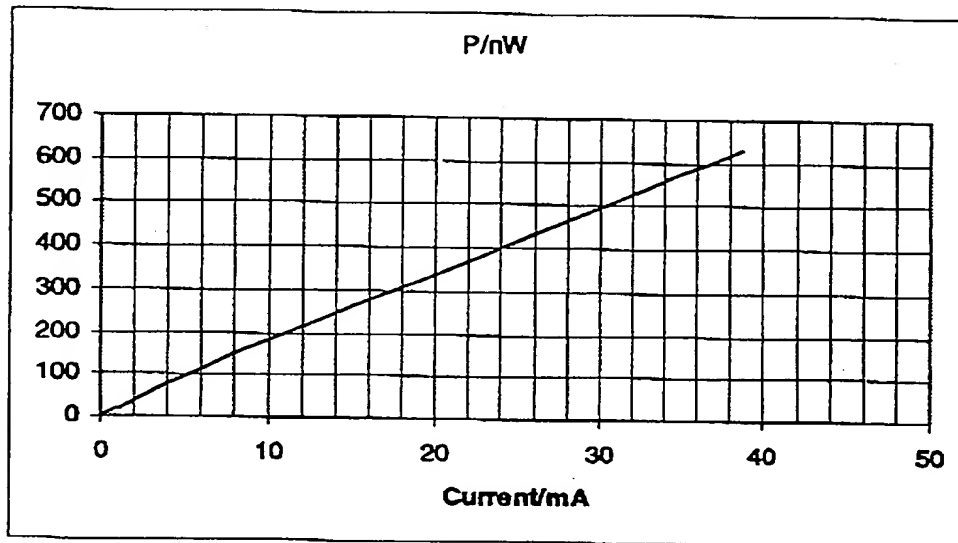
The LED source (11) would normally be too large a source for use in this system, and would result in a spot with too great an angular extent. In order to overcome this limitation, a metal mask with a small (typically  $60\mu\text{m}$ ) aperture is placed over the LED to limit its size.

Such sights have the disadvantage that their power consumption is high leading to short battery life.

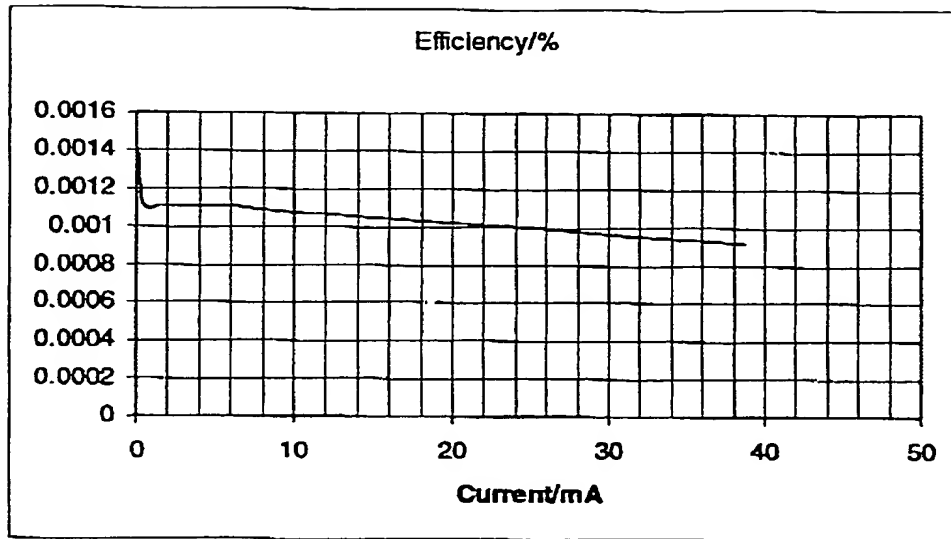
Our invention concerns the use of a laser diode source in a red-dot weapon sight, and of techniques which are used to detect when the sight is in use and to power off the sight when it is not in use. These lead to increased battery life and essentially a maintenance-free sight.

## LED Efficiency

Measured results from a typical weapon sight LED are shown on the figures below.







The calculated electrical-to-optical efficiency is  $\sim 0.001\%$ .

#### Laser Diode efficiency

We have based our calculations on a representative laser diode, the Sony SLD1122VS. This device gives an optical output power of 5mW at a forward current of 50mA and forward voltage of 2.2V. The input power is therefore 110mW, and the electrical-to-optical efficiency is 4.5%. Note that this efficiency drops if we drive the laser at lower current, due to the non-lasing contribution of the threshold current.

#### Design for a laser based sight

From the above sections, it is clear that moving to a laser diode will yield a significant increase in the overall efficiency of the sight. This is due to:

- The considerably higher electrical-to-optical efficiency of the laser
- The ability to shift to a more efficient wavelength of 670nm

#### Electronic design

The use of a laser diode introduces a complication, due to the laser light-current characteristic. There is a threshold current, below which the device does not lase. Control of the output power by control of the laser current (as is used with an LED) is difficult using a laser diode, particularly for low output power. This is because the threshold current varies from device to device, and is also temperature dependent. A

better solution is to drive the laser into the lasing region, and to control the output power using pulse width modulation.

If we assume that we require an average optical output power of  $1\mu\text{W}$ , which is typical for an LED used in a sight, then we need to drive the laser at a duty cycle of  $1\mu\text{W}/5\text{mW} = 2 \times 10^{-4}$ . The average current taken by the diode is then  $2 \times 10^{-4} \times 50\text{mA} = 10\mu\text{A}$

We have built a pulse width modulator circuit to demonstrate this technique. The circuit consists of an oscillator, used to set the base frequency of the pulse train at  $\sim 100\text{Hz}$  (fast enough that the eye does not detect the modulation), and a monostable, which sets the pulse width. Due to the high output power of the laser, maximum output is achieved using a pulse width of  $2\mu\text{s}$ , corresponding to a duty cycle of  $2 \times 10^{-4}$ . The oscillator and monostable functions have been implemented using the two halves of a 74HCT123 monostable, which operates down to  $3\text{V}$ . The current draw of the circuit is  $\sim 20\mu\text{A}$ , rising to  $\sim 30\mu\text{A}$  at 'full' output and hence significant proportion of the total current is required to supply the quiescent current of the circuit. However, at full power this is in excess of 3 orders of magnitude below the current required to operate the LED run at similar brightness.

### Optical design

The LED in existing sights has a metal mask, which creates a source of  $60\mu\text{m}$  diameter. The source is an approximately Lambertian emitter. The laser diode is a considerably smaller emitter, and has a source size of typically  $1\mu\text{m} \times 3\mu\text{m}$ . The beam has an approximately Gaussian profile, and has beam divergence of typically  $30^\circ \times 10^\circ$  (FWHM). The laser diode could be used with the existing optics, but would result in a spot of  $\sim 6$  arc seconds. The laser beam can be modified to produce a  $60\mu\text{m}$  source (as described in the paragraph below), and would then produce the same 3 arc minute angular extent as the LED when used with the existing optics. However, the angular resolution of the average human eye is approximately 1 arc minute. Thus the eye does not see the laser spot as being significantly different from the LED spot.

In order to modify the laser beam, it is worth noting that the laser diode source is close to diffraction limited. If we are to produce a  $60\mu\text{m}$  source with a beam divergence sufficient to fill the lens, we need to reduce the 'coherence' of the laser source such that it is  $\sim 60$  times diffraction limited. We believe that this can be done using diffractive optics, which would provide the necessary magnification of the source whilst increasing the beam divergence over the diffraction limited value.

## **Laser Safety**

We have performed a safety analysis for a laser diode driven in the fashion described above. The calculations were performed using LaserSafe PC software. The following parameters were used, based on a typical red-dot sight:

Wavelength:	670nm
Pulse energy:	10nJ (5mW for 2 $\mu$ s)
Exposure duration:	30,000 seconds
Beam diameter:	25mm (sight exit pupil diameter)
Beam divergence:	1mrad
Pulse repetition frequency:	100Hz
Pulse width:	2 $\mu$ s

The calculated accessible emission is  $0.17 \times$  the MPEL (Maximum Permissible Exposure Limit) and hence the system can be classified as Class 1 eye safe.

We have also investigated the situation in which a fault condition leads to the laser being switch on permanently at 5mW. In this situation, the eye is protected by the blink reflex to  $0.4 \times$  MPEL

## **Power Saving Techniques**

### **Time-out mechanism**

The most simple solution would be to build in time-out circuitry. This would simply turn the source off after a predetermined length of time – say, 1 hour. When the source switched off, the user would just press a conveniently located button to turn it back on and begin the next 1 hour of the source being turned on. It would be possible to have different settings for different lengths of time-out, e.g. there could be a “long operation” setting as well as the standard 1 hour setting which would allow, say, 5 hours of operation before time-out.

### **Motion Sensor**

When the gun is being held by the user, vibrations and motion can be detected by, say, a piezoelectric element. When no motion is detected, the source in the sight could be switched off. The motion signal could be integrated and the decision to switch off the source will be taken if the integrated signal falls below a certain threshold. The motion

sensor would also be triggered when the weapon was in transit. Therefore, the source should not have an automatic ON-switch, but should be manually switched on when required.

### **Tilt Switch**

Typically weapons are stored in a different orientation to that in which they are shot. Either they may be stored vertically, or lying on their side, and they tend to be shot horizontally and upright. A tilt sensor could be incorporated into the gun to detect when the gun is in a normal orientation for shooting. When not in a "shooting" position, the source could be switched off.

It would be desirable to have an override option which allowed the source to be on while no motion was detected by the motion sensor and while the gun was in a "non-shooting" orientation. This override could perhaps be protected by a time-out mechanism to prevent the source being left on unintentionally.

### **Detection of Ambient Light**

For daytime usage, a photodiode could be used to detect ambient light. When the amount of light is below a certain threshold level, the current could be reduced to its minimum setting. This will allow operation of the sight at night and will also reduce the power consumption to its minimum level when the gun is stored in the dark. Obviously if the weapon is stored in a light area, this solution will not work. Once again, an automatic ON/INCREASE-switch is undesirable in this situation.

### **Grip or Trigger Sensor**

A sensor which detects when the gun is being held in the firing position could be used to control whether the source is on or off. The grip of the weapon or the trigger would be appropriate places to mount such a sensor, which may be an electrical contact method or a piezoelectric or resistive element. This solution requires a communication between the gun and gunsight which would be done either via a direct electrical contact or by a wireless link.

### **Detect the Presence of the Eye**

The source only requires to be on when the user is actually looking into the gun sight. Therefore, a good method of determining when the sight is being used is to detect the presence of the eye. If a low level IR source was mounted inside the sight and facing

towards the location of the eye, when the eye was present there would be reflection of the IR from the cornea and retina which could be detected to confirm the presence of a user. The red dot itself could also actually be used as the illumination source which reflects off the eye. This solution would require less power since the sight would then contain only one source. By pulsing the source, the reflected light could be distinguished from ambient light.

The periodic blinking of the eye could be used as confirmation that the sight is being utilised. Combining detection of the eye reflection and the interruptions caused by blinking would enable reflection from inanimate items or other body parts to be distinguished.

#### **Detect Heat from the User**

The heat radiated from the user's face would also be another convenient method for detecting when the sight is in use. A sensing element, such as a temperature sensitive resistor, could be mounted at the entrance of the gun sight. This solution would run into problems in hot environments or when the hand, say, was close to the sight while the gun was being carried.

#### **Detect Breathing**

The vibration introduced by the user's breathing would be another triggering mechanism which could be used to monitor when the source in the sight is required to remain on. A motion or vibration sensor, such as a piezo electric element or an accelerometer could be used as the sensing element.

#### **Communication with User Badge/Tag**

Another method of determining when the gun and sight were with a user would be via a tag or badge which was worn by the user. A interrogator system in the sight would communicate with the badge/tag via a wireless link to confirm its presence and the source would only remain on while the badge/tag was in range.

#### **Voice-activated switch**

A voice-activated pressure sensor could be used as a switch to turn the source on or off at the user's command. This could be incorporated as the manual-ON switch. The system would incorporate a voice recognition system to prevent use by unauthorised persons, and to prevent triggering by ambient noise.

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